LOCALIZATION AND CLASSIFICATION OF ABNORMALITIES IN MEDICAL IMAGES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Nos. 62/684,337, filed Jun. 13, 2018 and 62/687,294, filed Jun. 20, 2018, the disclosures of which are herein incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates generally to localization and classification of abnormalities in medical images, and more particularly to localization and classification of abnormalities in medical images using a jointly trained localization network and classification network.

BACKGROUND

[0003] Currently, medical imaging technology is able to provide detailed views of the anatomy, various physiological processes, and metabolic activities within the human body in a non-invasive manner. However, with the increasing resolutions of medical images, the variety in the contrasts of medical images, and the use of multi-modal imaging, it is becoming prohibitively time-consuming for radiologists to evaluate medical images to identify abnormalities such as, e.g., fractions, bleeding, and lesions. Furthermore, the variety of abnormalities and how they manifest in the medical images make it difficult for radiologists to learn how to identify abnormalities in the medical images.

[0004] One exemplary medical imaging technology is multi-parametric magnetic resonance imaging (mpMRI), which has been proposed for the non-invasive diagnosis, localization, risk stratification, and staging of prostate cancer. An mpMRI image combines a number (e.g., 8 or more) of individual images acquired under different imaging protocols. Accordingly, a comprehensive assessment of an mpMRI image can be tedious for daily clinical readings. Further, subtle and collective signatures of cancerous lesions within the mpMRI image are difficult to detect consistently.

BRIEF SUMMARY OF THE INVENTION

[0005] In accordance with one or more embodiments, systems and methods are provided for classifying a lesion in a medical image. An input medical image depicting the lesion is received. The lesion is localized in the input medical image using a trained localization network to generate a localization map. The lesion is classified based on the input medical image and the localization map using a trained classification network. The classification of the lesion is output. The trained localization network and the trained classification network are jointly trained.

[0006] In one embodiment, the trained localization network and the trained classification network are jointly trained by separately training the localization network to determine weights of the localization network during a first training phase, and training the classification network based on the weights of the localization network during a second training phase. The localization network may be separately trained by receiving a multi-site dataset associated with different clinical sites and a deployment dataset associated with a deployment clinical site, training a deep learning model based on the multi-site dataset, and optimizing the trained deep learning model based on the deployment dataset to provide the trained localization network. The deep learning model may be trained by reordering a second dataset of the multi-site dataset based on a similarity of a first dataset of the multi-site dataset and the second dataset, and determining the trained deep learning model based on a pretrained deep learning model and the reordered second dataset. The trained deep learning model may be optimized by reordering an annotated deployment dataset of the deployment dataset based on an uncertainty, and determining the optimized deep learning model based on the trained deep learning model and the reordered annotated deployment dataset.

[0007] In one embodiment, the input medical image is a multi-parametric magnetic resonance imaging (mpMRI) image comprising a plurality of images. The lesion may be localized in each of the plurality of images using the trained localization network to generate a localization map for each of the plurality of images. The lesion may be classified by combining the localization maps for the plurality of images, and classifying the lesion based on the plurality of images and the combined localization maps using the trained classification network. The plurality of images of the mpMRI images may be preprocessed to address variances between the plurality of images. For example, the plurality of images may be preprocessed by removing geometric variability in the plurality of images of the mpMRI image or by normalizing intensity variability in the plurality of images of the mpMRI image.

[0008] In one embodiment, the localization map may be associated with a score of the lesion.

[0009] These and other advantages of the invention will be apparent to those of ordinary skill in the art by reference to the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** shows a method for localizing and classifying lesions in a medical image, in accordance with one or more embodiments;

[0011] FIG. **2** shows a network architecture of a multi-task network, in accordance with one or more embodiments;

[0012] FIG. **3** shows a network architecture of a multi-modality fusion network, in accordance with one or more embodiments;

[0013] FIG. **4** shows a network architecture of a regression network, in accordance with one or more embodiments;

[0014] FIG. **5** shows a method for detecting an abnormality in a medical image, in accordance with one or more embodiments;

[0015] FIG. **6** shows a workflow for detecting an abnormality in a medical image, in accordance with one or more embodiments;

[0016] FIG. **7**A shows an exemplary incomplete image, in accordance with one or more embodiments;

[0017] FIG. **7**B shows an exemplary synthesized image, in accordance with one or more embodiments;

[0018] FIG. **8** shows a method for training a deep learning model based on a multi-site dataset, in accordance with one or more embodiments;

[0019] FIG. **9** shows a method for training a deep learning model based on a multi-site dataset, in accordance with one or more embodiments;